

# Easy-to-Clean Surfaces and the Underlying Nanoscale Materials

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# Macroscopic Effects with Nanoscale Surfaces



**Increasing attention is being given to surfaces that**

- are nanoscale thick coatings, or
- macroscopic coatings with controlled roughness at the nanoscale, or
- macroscopic coatings that uniformly distribute and fix photocatalytically active particles of a size to optimize light scattering

**These surfaces may have environmentally desirable characteristics known as**

- Easy-to-Clean;
- Lotus Effect®
- Self-Cleaning

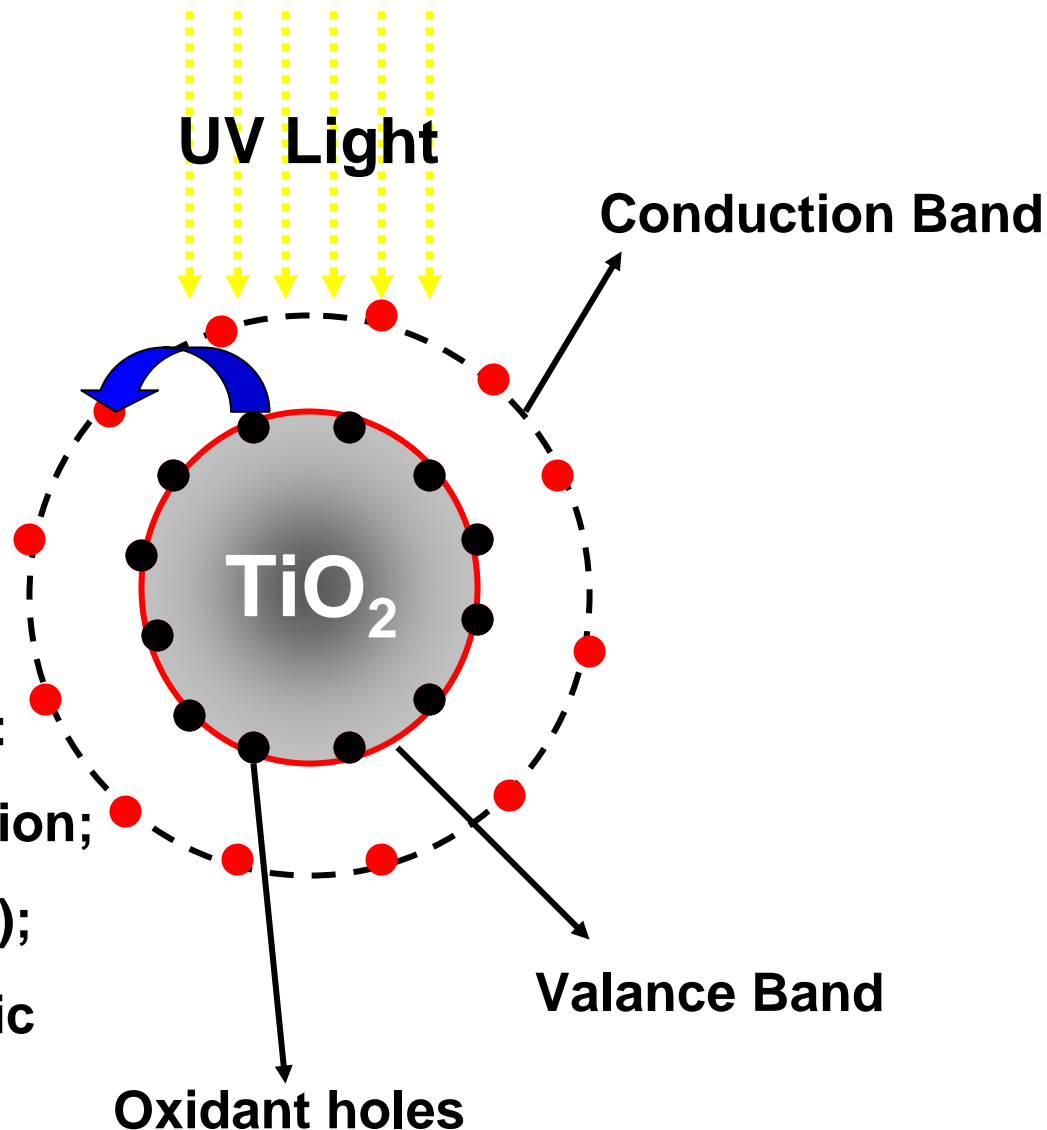
**Examples of each are given along with limitations**

# The Photo-catalytic Process

- Photon absorption;
- band promotion;
- potential gaps formed.

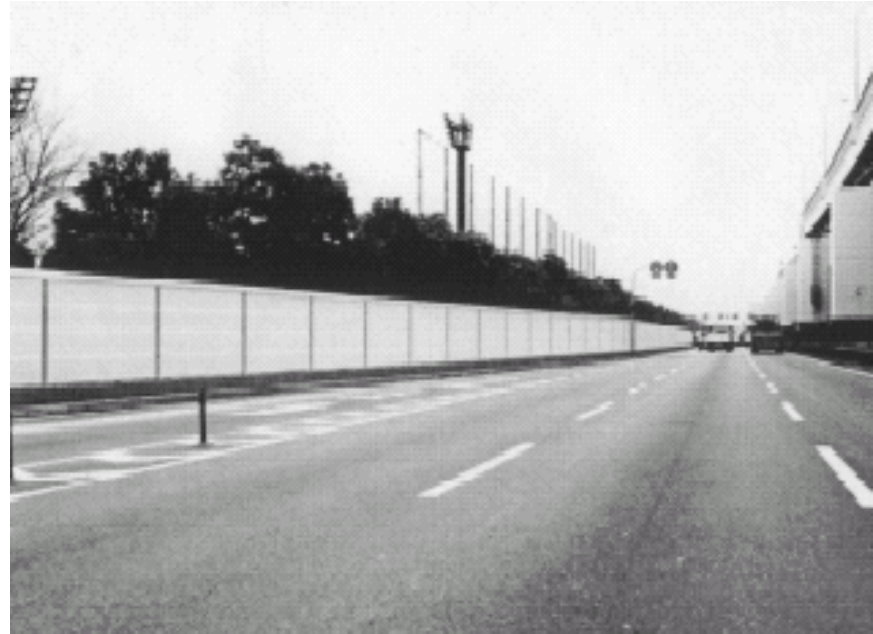
In the presence of  $\text{H}_2\text{O}/\text{O}_2$ :

- hydroxyl radicals formation;
- oxidation/reduction ( $\text{OH}^\cdot$ );
- destruction of the organic compounds.



# Environmental Friendly Applications

**Highway wall painted with Titanium Dioxide to help with the elimination of gases emitted by vehicles such as (NO<sub>x</sub>) Osaka, 1999**



**2. Indoor air purification by decomposing odors and ammonia.**



**Provision of drinkable water for rural populations. This project was initiated on 2002 in six Latin American Countries including Brazil.**



**Treating industrial waste water, for example waste water containing dyes**



# Self-Cleaning Building Coatings

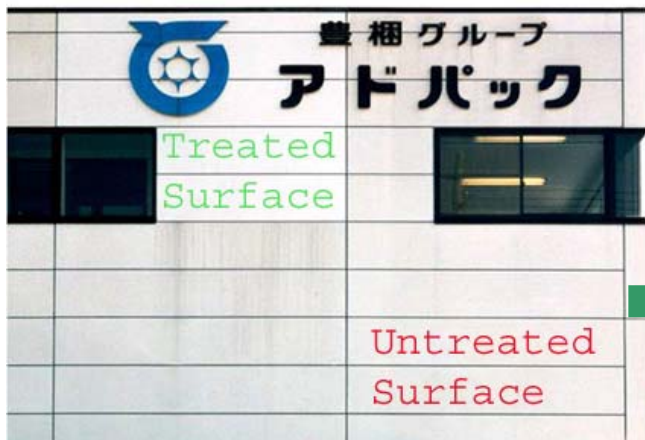
1999



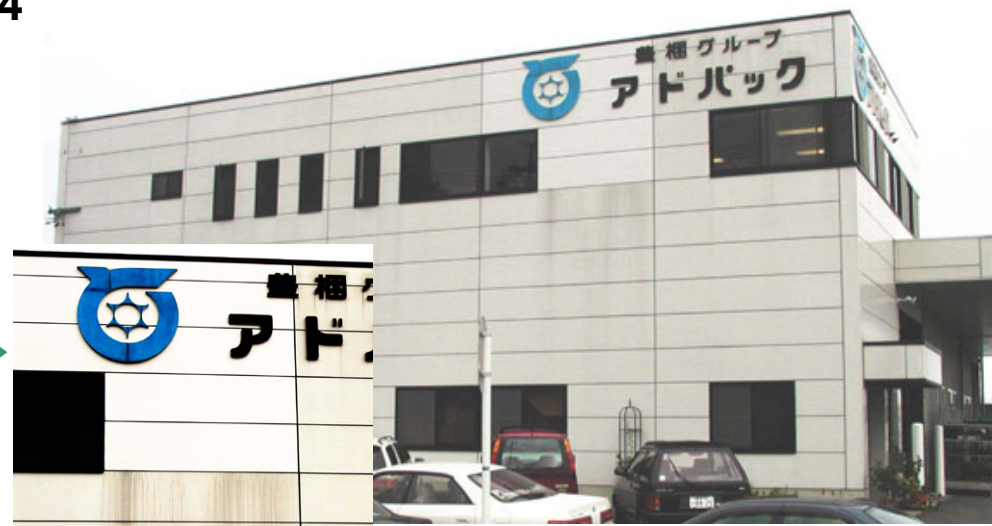
2004



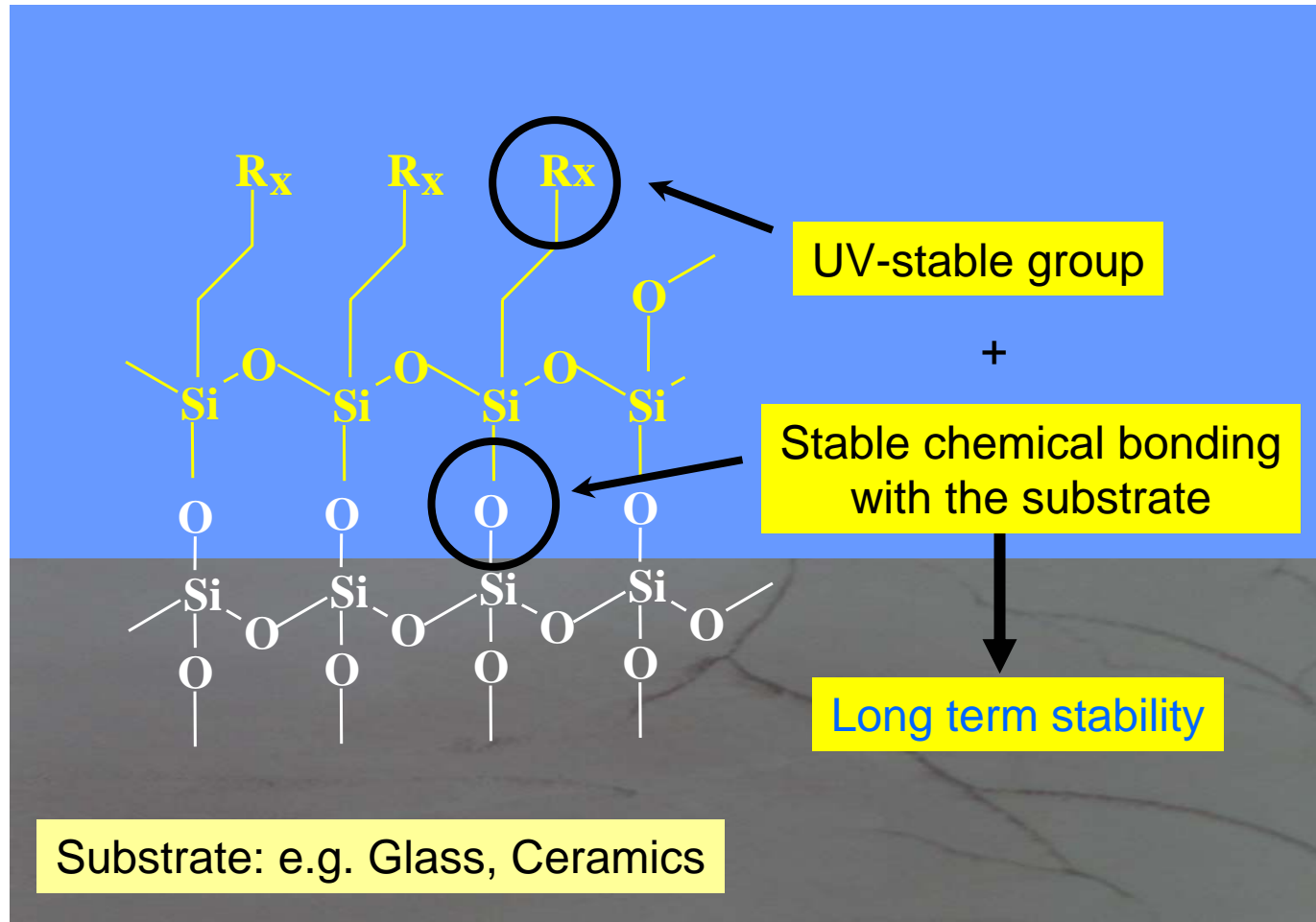
1999



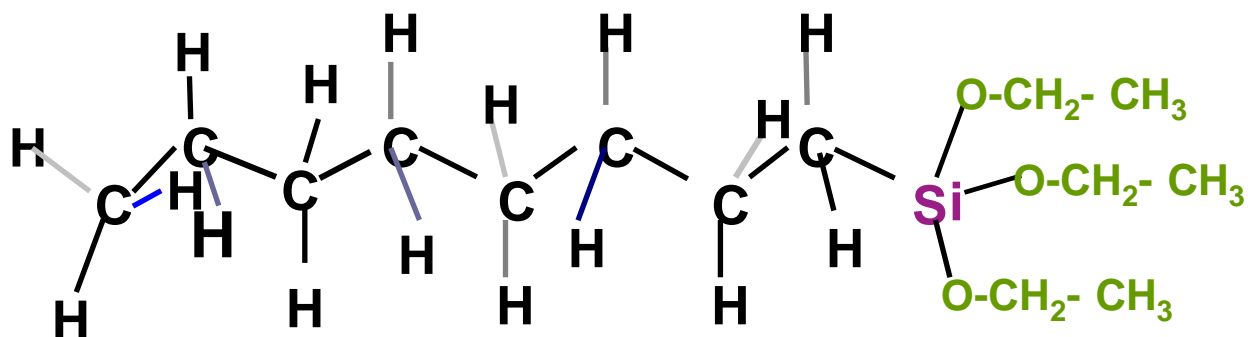
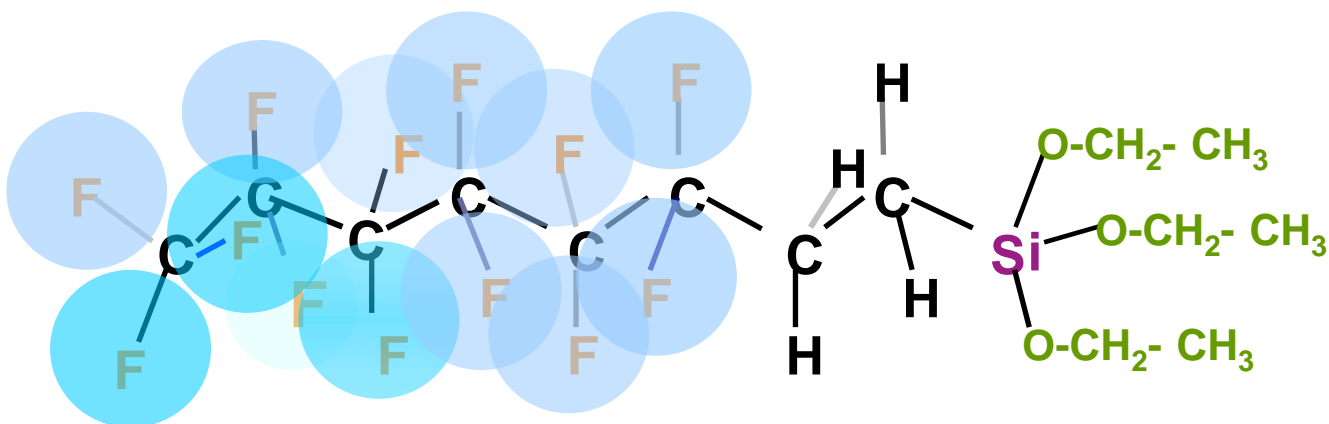
2004



# Easy-to-Clean Surface Films

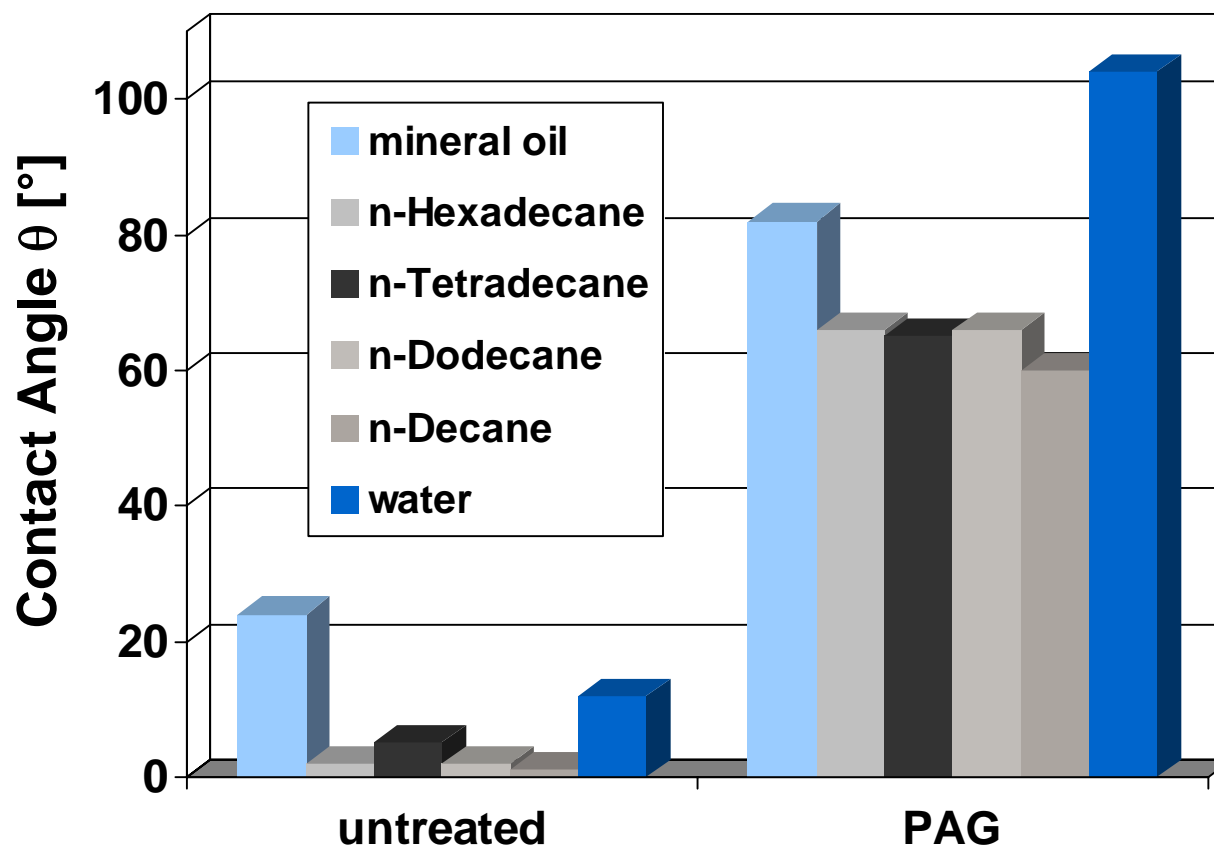


# Protectosil® AntiGraffiti and Traditional OCTEO



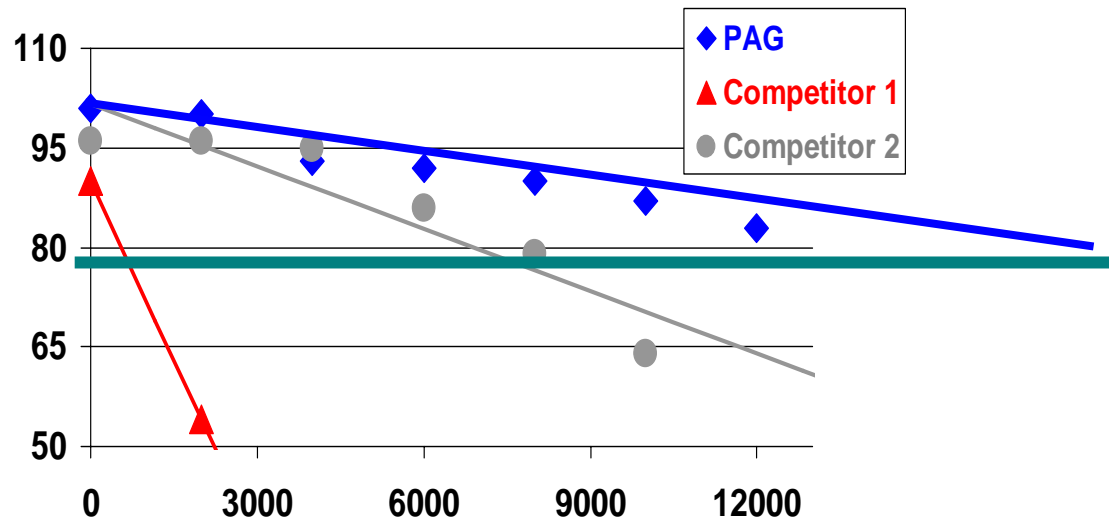


# Contact Angles of Various Liquids on Protectosil® Treated Glass



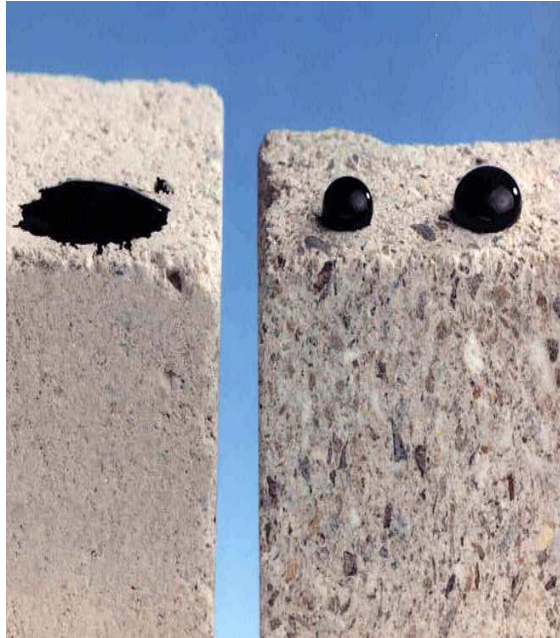
# Abrasion Test on Glass with Abrasive Pad/ Aluminium Silicate Slurry

Contact Angle  $\theta$  [°]



Number of Cycles

# Simultaneously Oleophobic and Hydrophobic Surface



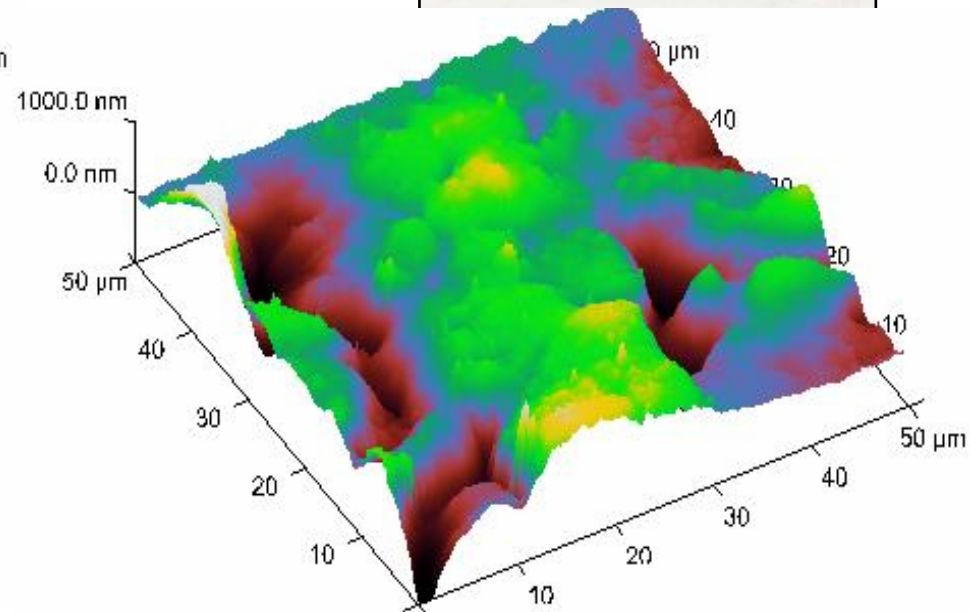
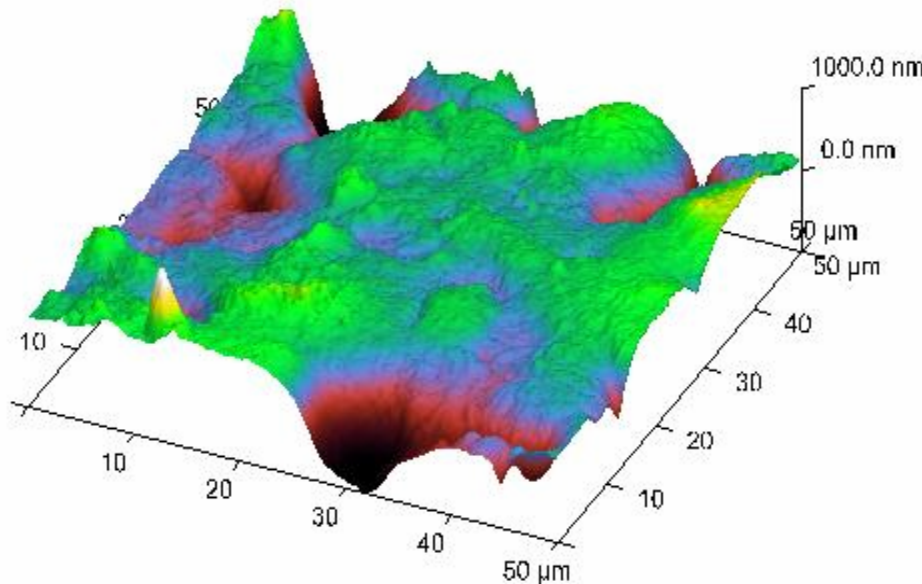
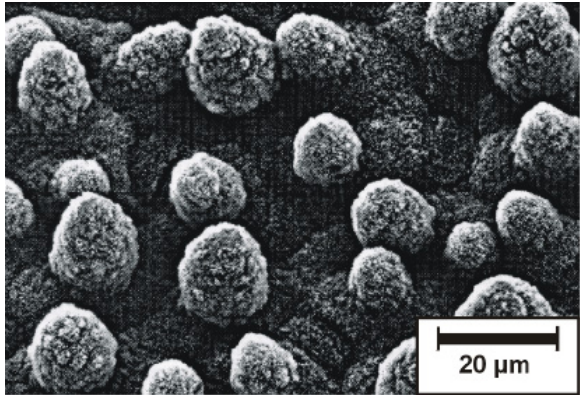
Unprotected

Protected

Durable Film After  
Nine Applications

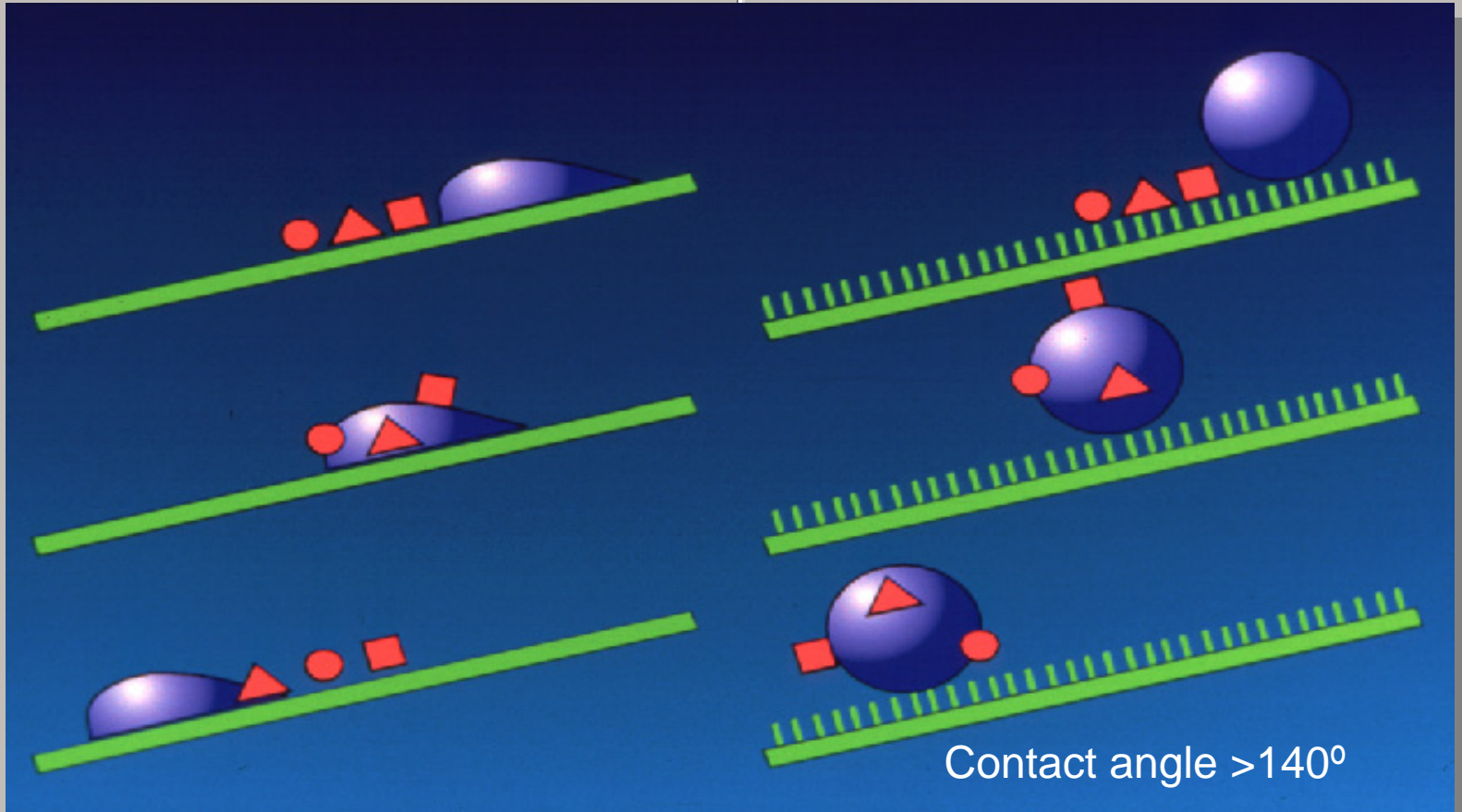


# Lotus Effect<sup>®</sup> Films as Self - Cleaning Surfaces





# Lotus-Effect® Films Effecting Self-Cleaning with Rainwater

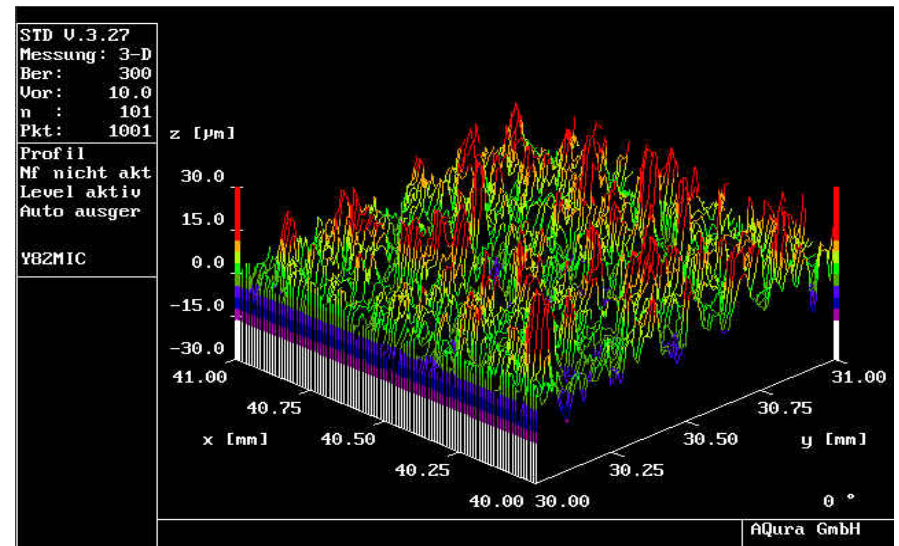
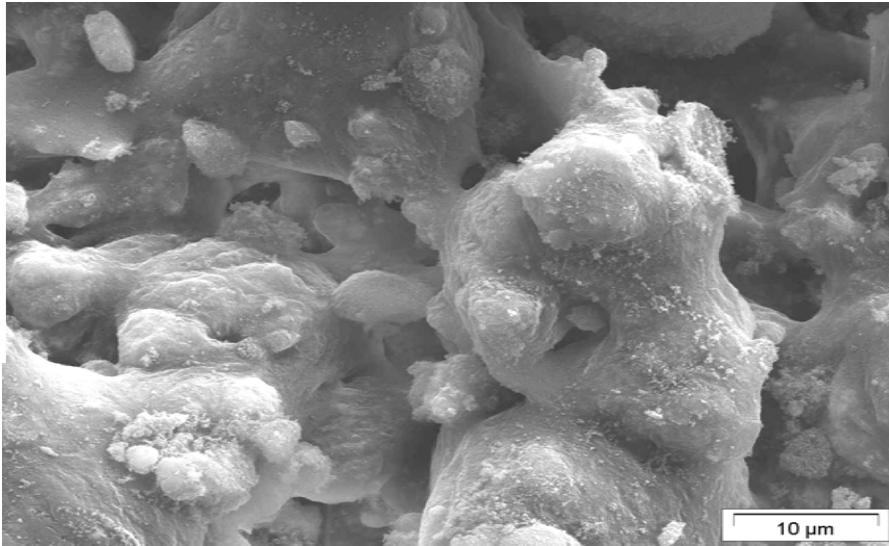
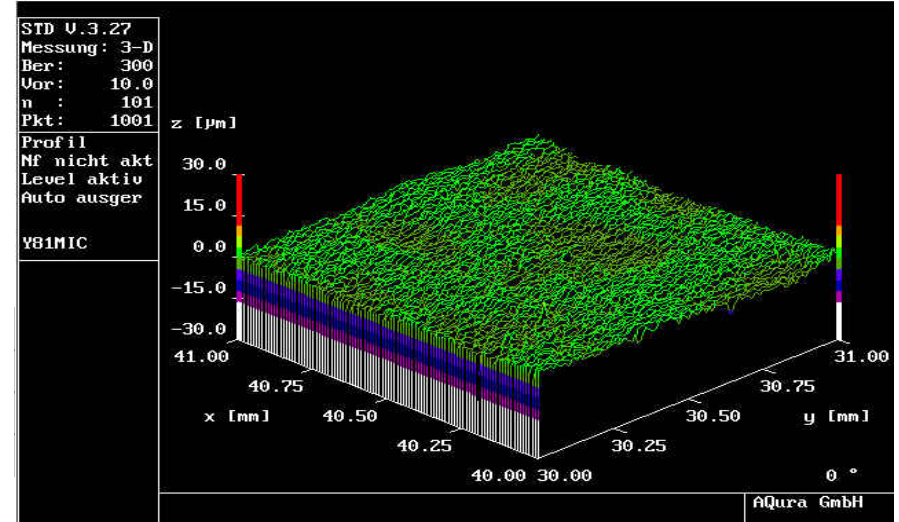
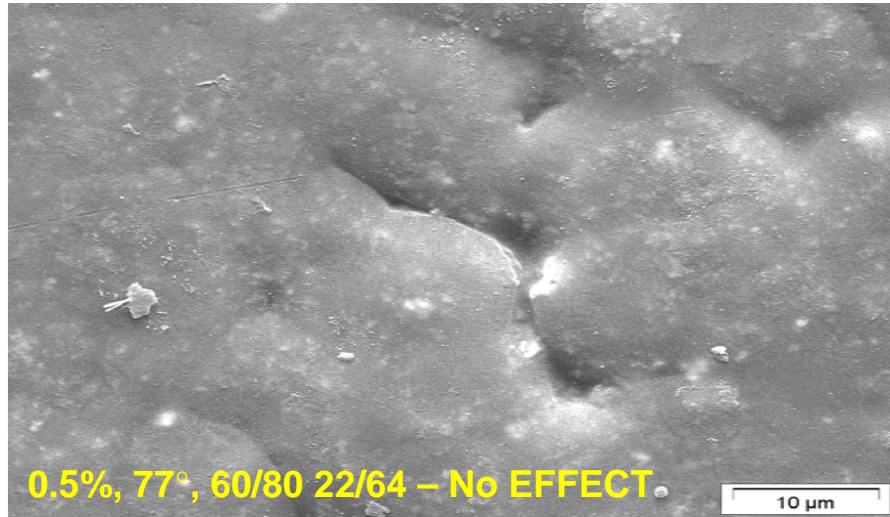


Smooth hydrophobic Surface  
(e.g. Teflon®)

Lotus-Effect® -Surface



# SEM Powder Coated Surfaces with and without Lotus Effect® Films



# Summary of Formulating with Nanostructured Particles



**The Lotus-Effect® film is ineffective in the presence of**

- Non-polar liquids such as cosmetic oils, solvents, .....
- Media containing surfactants
- Surface matting will occur when coating is applied

**Thin coating, <10 microns**

**Particles need to protrude out of the coating surface to create a highly irregular surface at the nanoscale, which is also hydrophobic.**

- Deposit a low surface energy layer, so dirt and water droplets do not adhere.
- Any hydrophilic points on surface will attract water and contact angle will not exceed 140 degrees.

# **1. There are multiple approaches for controlling surface attributes at the nanoscale**

- **Contact angle**
- **Surface roughness plus contact angle**
- **Catalytic activity**

# **2. Each has its advantages and disadvantages depending on application**

- **Durability: most durable requires deliberate washing and with detergents**
- **Amount of „dirt“ may overwhelm rain as motive force**
- **Light Scattering (needs access to light)**

# **3. One challenge remains uniformly applying a nanoscale effect using standard industrial technology**



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